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LESSON:

Carbon and Mercury Cycles

Summary: Students use information from the lesson and an article on forest fires to create a diagram of the carbon and mercury cycles. Students also identify gaps in their knowledge about the mercury cycle.

Lesson Type: Short Lesson—This lesson will take 20 to 30 minutes to implement. Graphic Organization & Modeling—This lesson has students organize information graphically (e.g., using figures, graphs, and/or webs) or by creating a model.

***EHP* Article:** "Forest Fire Fallout"
EHP Student Edition, April 2007, p. A21
http://www.ehponline.org/docs/2007/115-1/forum.html#fore

Objectives: By the end of this lesson, students should be able to

1. create a graphic model of the carbon cycle;
2. create a graphic model of the mercury cycle; and
3. identify interests or knowledge gaps about the mercury cycle.

Class Time: 20–30 minutes

Grade Level: 9–12

Subjects Addressed: Biology, Environmental Science, Geology, Chemistry

Prepping the Lesson (15 minutes)

INSTRUCTIONS:

1. Download the entire April 2007 *EHP Student Edition* at http://www.ehponline.org/science-ed/, or download just the article "Forest Fire Fallout" at http://www.ehponline.org/docs/2007/115-1/forum.html#fore.
2. Review the Background Information, Instructions, and Student Instructions.
3. Make copies of the Student Instructions.

MATERIALS (per student):

- 1 copy of the April 2007 *EHP Student Edition*, or 1 copy of "Forest Fire Fallout," preferably in color
- 1 copy of the Student Instructions
- Pens of different colors

VOCABULARY:

- biogeochemical cycle
- boreal forest
- carbon cycle
- carcinogen
- exacerbate
- fire emission
- hectare
- mercury cycle
- methylmercury
- peat
- respiration
- toxicity

BACKGROUND INFORMATION:

Most biology, environmental science, and geology classes cover the topic of the biogeochemical cycle of carbon. However, many people do not realize that mercury follows a similar biogeochemical cycle. A potentially toxic heavy metal, mercury is the only metal that is liquid at room temperature and in its elemental form can volatilize into the atmosphere. Although mercury can volatilize from rocks and soils that contain it, as well as be released into the atmosphere from volcanic eruptions, the largest quantities of mercury in the environment are released from burning coal.

Once in the atmosphere, mercury eventually falls to the Earth's surface and deposits itself onto vegetation, soil, and water. This deposited mercury can be transformed into organic or methylmercury by bacteria and then move up the food chain. This methylmercury becomes deposited in the tissue of animals, and larger carnivorous animals typically have higher concentrations of stored mercury because of bioaccumulation. This is why large fish like tuna should be eaten in moderation compared to smaller fish like tilapia or trout.

The article mentions that methylmercury may be carcinogenic, but the primary known health effect of methylmercury is damage to the brain/nervous system and kidneys. Mercury is particularly problematic for developing fetuses, babies, and children. For more information about the health effects of mercury and other *EHP Student Edition* lessons on mercury, visit the websites listed in the Resources section below.

RESOURCES:

Environmental Health Perspectives, Environews by Topic page, http://ehp.niehs.nih.gov/. Choose Mercury, Metal Toxicity, Systems Biology

EHP Student Edition lesson, "Lead and Mercury: Comparing Two Environmental Evils," May 2006, http://www.ehponline.org/science-ed/

EHP Student Edition lesson, "Toxic Tic-Tac-Toe," January 2006, http://www.ehponline.org/science-ed/

EHP Student Edition lesson, "Using a Spoon to Clean the Air," February 2005, http://www.ehponline.org/science-ed/

Environment Canada, Mercury and the environment: biogeochemistry, http://www.ec.gc.ca/MERCURY/EH/EN/eh-b.cfm?SELECT=EH

University of Wisconsin–Eau Claire, Mercury in the environment and water supply: the mercury cycle, http://www.uwec.edu/piercech/Hg/mercury_water/cycling.htm

U.S. Environmental Protection Agency, Carbon cycle animation, http://www.epa.gov/climatechange/kids/carbon_cycle_version2.html

U.S. Environmental Protection Agency, Mercury health effects, http://www.epa.gov/mercury/effects.htm

Wikipedia, Carbon cycle, http://en.wikipedia.org/wiki/Carbon_cycle

Implementing the Lesson

INSTRUCTIONS:

1. Distribute the Student Instructions and the article.
2. Review the instructions and carbon cycle as needed—the lesson provides a brief introduction to the carbon cycle. Students do not have to have extensive background knowledge of the carbon cycle to complete the lesson.

NOTES & HELPFUL HINTS:

1. A more detailed carbon and mercury cycle could include examples of the various chemical forms of mercury and carbon in the cycle.
2. Teachers of students in lower grade levels (9 and 10) may want to help students set up the diagram, perhaps by drawing one example of carbon exchange in the diagram.
3. Chemistry and biochemistry classes could investigate the chemical and biochemical reactions that change mercury and carbon from one form to another.

Aligning with Standards

SKILLS USED OR DEVELOPED:

- Classification
- Communication (note-taking, oral, written—including summarization)
- Comprehension (listening, reading)
- Critical thinking and response
- Observation

SPECIFIC CONTENT ADDRESSED:

- Carbon cycle
- Forest fires
- Mercury sources
- Mercury cycle

NATIONAL SCIENCE EDUCATION STANDARDS MET:

Science Content Standards

Unifying Concepts and Processes Standard

- Systems, order, and organization
- Evidence, models, and explanation
- Change, constancy, and measurement
- Evolution and equilibrium
- Form and function

Science as Inquiry Standard

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Physical Science Standard

- Structure and properties of matter
- Chemical reactions

Life Science Standard

- Interdependence of organisms
- Matter, energy, and organization in living systems

Science and Technology Standard

- Abilities of technical design
- Understanding about science and technology

Earth and Space Science Standard

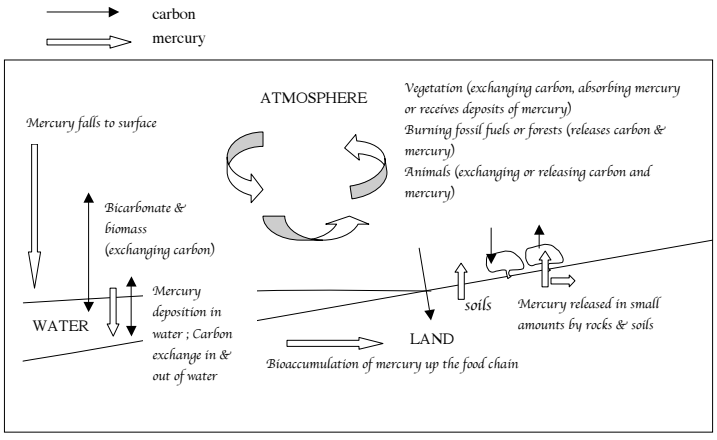
- Geochemical cycles
- Historical perspectives

Science in Personal and Social Perspectives Standard

- Natural resources
- Environmental quality
- Natural and human-induced hazards

Assessing the Lesson

Step 1: Using the description of the carbon cycle as your guide, label the diagram on the next page to complete a visual depiction of the carbon cycle.



Students can draw a variety of pictures but should include an accurate depiction of the information included in the lesson and article. Using a different color, students will add mercury to the diagram in Step 3. The mercury cycle should closely resemble the carbon cycle. The diagram should include combustion as a major means of releasing mercury and carbon into the atmosphere. Students should also depict the bioaccumulation of mercury up the food chain.

Step 3: Using the information from the article and the diagram of the carbon cycle in Step 1, show how mercury relates to the carbon cycle.

Refer to the completed diagram in Step 1 above.

Step 4: What questions do you have or additional information do you need to generate a more complete understanding of the mercury cycle?

Student responses will vary. Look for logical questions that demonstrate understanding and curiosity. For example, a student may wonder how mercury becomes methylmercury or want details of how methylmercury moves through the food chain.

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Give us your feedback! Send comments about this lesson to ehpscienceed@niehs.nih.gov.

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Student Instructions: Carbon and Mercury Cycles

Step 1: The carbon cycle is the natural exchange of the element carbon between the Earth's atmosphere, living matter, the ocean, and geological formations. Carbon is considered to be the building block of life, and it is transformed into many different chemicals or molecules during the carbon cycle.

For example, in the atmosphere carbon primarily exists as carbon dioxide (CO_2), but in living things carbon bonds with many other elements (such as hydrogen and nitrogen), making chemicals like sugars and proteins. Plants, for example, take CO_2 from the air and use energy from the sun to make the molecules they need for living, such as sugars, cellulose, proteins, and other chemicals. Plants also release CO_2 into the air. When other living things eat plants or other animals, their cellular processes break down chemicals to obtain energy (for example, when we eat breakfast, we get energy). Carbon that was captured in the protein or sugar in the food is used to make new chemicals for bodily functions or is re-released via breathing or respiration as CO_2.

But this is only one small part of the cycle. A large amount of carbon is stored in the oceans as a molecule called bicarbonate and within the biomass (or living matter) in the ocean. Carbon is also stored and exchanged in soils (and the microorganisms in soils), rocks (such as limestone), and fossil fuels (such as oil and coal). Carbon stored in fossil fuels is released when burned (for example, coal is burned for electricity, and gasoline runs vehicles).

Using the above description of the carbon cycle as your guide, label the diagram on the next page to complete a visual depiction of the carbon cycle.

Step 2: Read the article "Forest Fire Fallout."

Step 3: Mercury is a potentially toxic heavy metal that has very unique properties. It is the only metal that is a liquid at room temperature and can evaporate into the air. Mercury is a naturally occurring element, and most of it is "bound" by rocks, fossil fuels, or other geological formations. Although mercury is naturally released into the environment by geologic formations and events (like volcanic eruptions), the largest amounts of mercury are released by burning coal for electricity (coal-fired power plants).

Using the information from this lesson and article, show the mercury cycle on the diagram in Step 1. You may want to use a different color of pen to depict the mercury cycle. You may label the diagram to more clearly describe the processes.

Step 4: What questions do you have or additional information do you need to generate a more complete understanding of the mercury cycle?

Carbon and Mercury Cycle Diagram